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RESEARCH ARTICLE

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A taxonomic revision of *Adonis* (Ranunculaceae) in Kazakhstan

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Abstract

In this study, we conducted a taxonomic revision of the genus *Adonis* in Kazakhstan based on herbarium specimens and field observations collected between 2021 and 2025. In addition, we assessed the distributions and regional conservation status of each taxon. As a result, eight taxa were recognized, comprising six species and two subspecies. Among these, *A. aestivalis* subsp. *aestivalis* was identified as an introduced taxon in Kazakhstan. Regarding regional conservation status, one species was categorized as endangered, two species as vulnerable, three species as near threatened, and three species as of least concern. Identification keys and detailed taxonomic treatments are provided for all known *Adonis* taxa in Kazakstan, along with notes on their distribution, habitat, and examined specimens. Additionally, we have designated a lectotype for *A. chrysocyathus* in the present study. Based on our results, we recommend that *A. apennina* be included and *A. volgensis* excluded from the next edition of the Red Data Book of Kazakhstan. This study enhances our understanding of the systematics of *Adonis* in Kazakhstan and provides a foundation for further floristic and conservation studies.

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Keywords
Asia, Altai, biodiversity, conservation status, flora, taxonomic revision

Introduction

The genus *Adonis* L., comprising 26–38 species, belongs to tribe Adonideae of the Ranunculaceae family (Tamura 1990, 1991; Son et al. 2016; Conti et al. 2023). According to Plants of the World Online (POWO 2025), 35 species are currently recognized worldwide. This genus is commonly distributed in southwestern Asia, Europe, Northern Africa, and the Mediterranean region (Tamura 1990). *Adonis* is divided into two subgenera: *Adonanthe* (Spach) W.T.Wang (perennials) and *Adonis* (annuals) (Tamura 1990). Morphologically, members of *Adonis* are characterized by compound leaves that are 1–2 palmately or 2–3 pinnately dissected, terminal inflorescences, and white, red, or yellow flowers with petals without nectaries (Tamura 1991; Son et al. 2016; Sennikov 2023). Furthermore, *Adonis* exhibits spirally arranged, apocarpous gynoecia composed of numerous simple carpels, each with a single ovule, a short persistent style, and a small stigma. The fruit is an aggregate of achenes, often with a straight or slightly curved persistent beak, which serves as an important diagnostic character (Wang et al. 1994a, 1994b).

In Kazakhstan, approximately eight *Adonis* species have been recorded according to various sources (Abdulina 1999; Zhumagul et al. 2024). Among these, five species — *A. chrysocyathus* Hook.f. & Thomson, *A. tianschanica* (Adolf) Lipsch., *A. vernalis* L., *A. villosa* Ledeb., and *A. volgensis* DC. — have been included in the Red Data Book of Kazakhstan (Baitulin 2014). No endemic species of the genus *Adonis* have been recorded in Kazakhstan (Kubentayev et al. 2024a). Recently, several studies on the population size, distribution and genetic diversity of *A. tianschanica* (Kulymbet et al. 2023), and distribution range of *A. vernalis* and *A. volgensis* in Kazakhstan (Beishova et al. 2019; Kubentayev et al. 2019; Sultangazina et al. 2020, 2022; Aidarkhanova et al. 2022; Zhumagul et al. 2023, 2025; Alibekov et al. 2025; Orazov et al. 2025) have been conducted. Additionally, the distribution ranges of some other species in the country have been partially updated (Zhumagul et al. 2024). Despite these studies, a comprehensive taxonomic revision of *Adonis* species in Kazakhstan has not yet been conducted. Furthermore, there is a lack of detailed analysis regarding their distribution within the country, making it difficult to assess population and regional conservation statuses. This study is a continuation of our previous taxonomic research on the flora of Kazakhstan (Kubentayev et al. 2021, 2023, 2024b, 2025).

The aims of this study were to (1) expand the current knowledge on general morphology and distribution; (2) address taxonomic issues based on type identification; and (3) provide a clear taxonomic treatment with informative descriptions and illustrations of the *Adonis* species in Kazakhstan.

Material and methods

Plant distribution data

Species occurrence data were obtained from four main sources: (i) field survey observations conducted between 2020 and 2025; (ii) literature and publications; (iii) herbarium collections from AA, KG, KSPI, KUZ, LE, MW, and NUR (Thiers 2024); and (iv) records from the iNaturalist (https://www.inaturalist.org/) and Plantarium (https://www.plantarium.ru/) platforms. In particular, iNaturalist is one of the most widely used platforms for biodiversity research worldwide (Baasanmunkh et al. 2025; Mason et al. 2025). Additionally, we examined herbarium collections of Kazakh National University (KNU). During the field surveys, we collected approximately 12 specimens which were deposited in the NUR. The wild photographs of *Adonis* species were taken by authors during the field surveys. Furthermore, supplementary photographic material was sourced from the iNaturalist and Plantarium databases. The distribution maps (Fig. 2) of the species were compiled in ArcGIS 10.3 (Esri 2012).

Assessment of regional conservation status

The regional conservation status of each species was assessed under Red List Criterion B in accordance with International Union for Conservation of Nature IUCN national Red List guidelines (IUCN 2012). Criterion B uses geographic range the extent of occurrence (EOO), and the area of occupancy (AOO), along with supporting evidence of population decline, fragmentation, or fluctuations, to determine extinction risk. The EOO and AOO were estimated using the GeoCAT tool (Bachman et al. 2011) . The AOO was calculated using a user-defined grid cell size of 2 km^2, as recommended by the IUCN (2024).

Results and discussion

Based on our findings, we confirmed the presence of eight *Adonis* taxa in Kazakhstan, including seven species, i.e., *A. apennina* L., *A. chrysocyathus*, *A. tianschanica*, *A. vernalis*, *A. villosa*, *A. volgensis*, and *A. aestivalis* L., this latter with two subspecies: *A. aestivalis* subsp. *aestivalis* and *A. aestivalis* subsp. *parviflora*. According to the floristic division of Kazakhstan (Fig. 1), the highest taxon diversity was found in the Altai and Trans-Ili Kungey Alatau regions, each hosting four taxa. Three species were distributed in both the Betpak-Dala and Dzungarian Alatau regions. The remaining regions contained only one or two species (Fig. 1).

Regarding regional conservation status, one taxon was categorized as endangered (*A. chrysocyathus*), two as vulnerable (*A. apennina* and *A. villosa*), two as near threatened (*A. tianschanica* and *A. vernalis*), and two as least concern (*A. aestivalis* subsp. *parviflora*

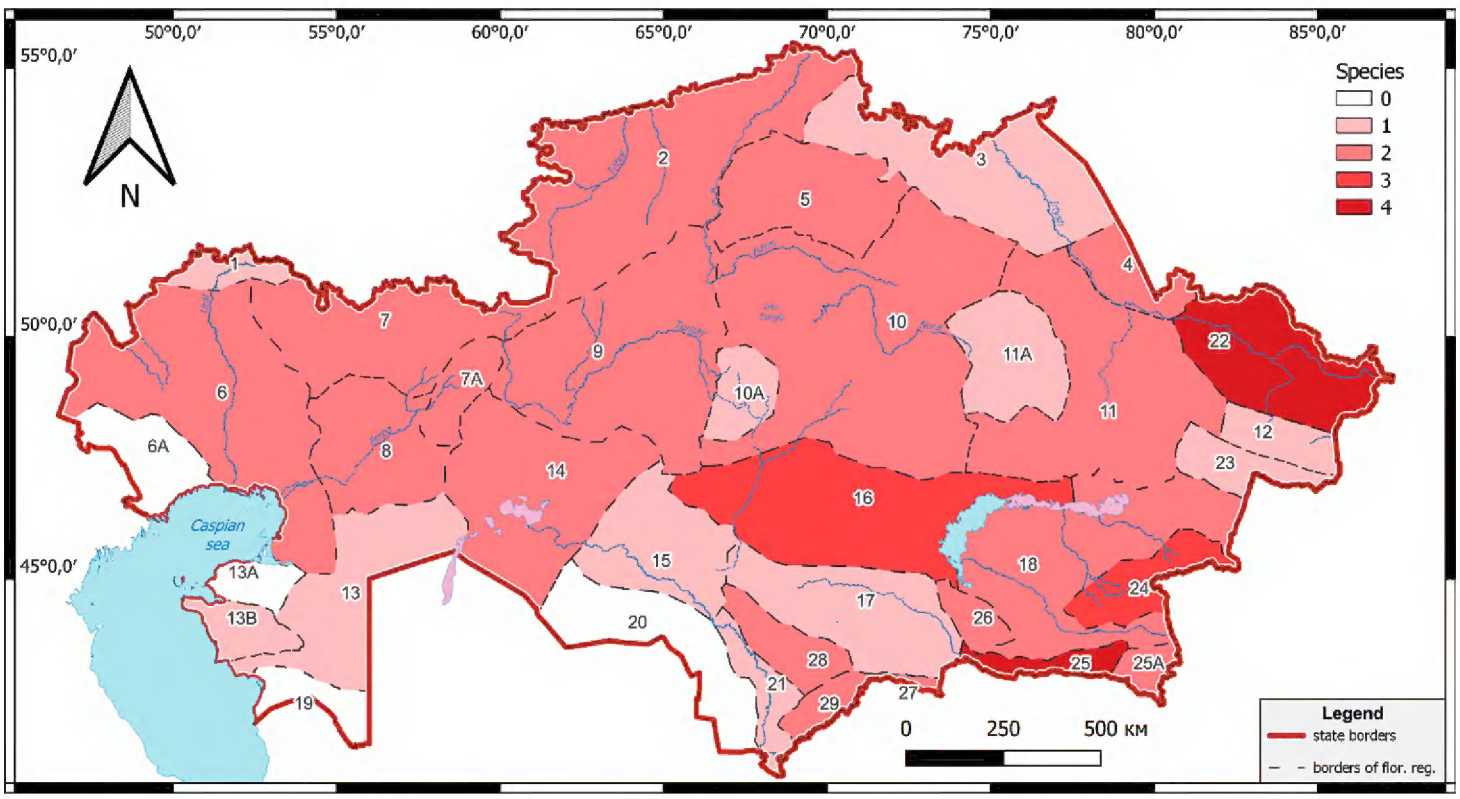

Figure 1. Species richness of the genus *Adonis* across the floristic regions of Kazakhstan according to Pavlov (1956). 1 – Syrt, 2 – Tobol-Ishim, 3 – Irtysh, 4 – Semipalatinsk pine forest, 5 – Kokchetav, 6 – Caspian region, 6A – Bukeev, 7 – Aktobe, 7A – Mugojary, 8 – Emba, 9 – Turgay, 10 – Western Upland, 10A – Ulutau, 11 – Eastern Upland, 11A – Karkaraly, 12 – Zaysan, 13 – Northern Ustyrt, 13a – Buzachi, 13B – Mangyshlak, 14 – Aral region, 15 – Kyzylorda, 16 – Betpak-Dala, 17 – Moiynkum, 18 – Balkhash-Alakol, 19 – Southern Ustyrt, 20 – Kyzylkum, 21 – Turkestan, 22 – Altai, 23 – Tarbagatai, 24 – Dzungarian Alatau, 25 – Trans-Ili Kungey Alatau, 25A – Ketmen -Terskey Alatau, 26 – Chu-Ili Range, 27 – Kyrgyz Alatau, 28 – Karatau, 29 – Western Tian Shan.

and *A. volgensis*). The conservation status of *A. aestivalis* subsp. *aestivalis* was not assessed because it is a non-native species in Central Asia. Based on our results, we recommend that *A. apennina* be included and *A. volgensis* excluded from the next edition of the Red Data Book of Kazakhstan.

Taxonomic key of *Adonis* in Kazakhstan

1 Herbs annual; flowers 0.9–3 cm in diameter; achenes with reticulate or wrinkled surface and comb-like margin (sect. (*Adonis*) **2**

– Herbs perennial; flowers 3–6 cm in diameter; achene smooth or s lightly tuberculate; comb-like margin absent (sect. *Adonanthe*) **3**

2 Flowers small (0.9–1.5 cm in diameter), pedicel exserted from apical leaves at anthesis; achenes distinctly wrinkled-reticulate with comb-like toothed margin, with one sharp tooth at the lower edge and two small teeth at the upper edge; stem usually simple ..... ***A. aestivalis* subsp. *parviflora***

– Flowers larger (1.8–3 cm in diameter), pedicel included in apical leaves at anthesis; achenes reticulate-dull-wrinkled with a small denticle on the lower part of the anterior side, slightly humped upper edge (the denticle of the upper edge is not expressed); stem branched ..... ***A. aestivalis* subsp. *aestivalis***

3 Stem leaves with petiole (up to 15 cm) at base of the stem; leaves towards apex shortly petiolate or sessile ..... ***A. chrysocyathus***
– All stem leaves sessile **4**
4 Stems 1–3 or branched from base, curly-haired; ultimate leaf segments oblanceolate ..... ***A. tianschanica***
– Stems solitary or few; not branched from base **5**
5 Leaves pinnately dissected **6**
– Leaves palmately dissected 7
6 Plants glabrous; flowers 4–6 cm in diameter; sepals glabrous.... ***A. apennina***
– Plants densely pubescent; flowers 2–4(5) cm in diameter; sepals hairy ..... ***A. villosa***
7 Terminal lobes of leaves filiform-linear, glabrous; flowers bright yellow, 4–4.5 cm in diameter; beak of achene strongly recurved against abaxial surface; habitat: forest-steppe and shrub ..... ***A. vernalis***
– Terminal lobes of leaves linear-lanceolate, pubescent; flowers pale yellow, 3–4.5 cm in diameter; beak of achene straight or straightly bent downwards; habitat: dry *Stipa-Festuca* steppes ..... ***A. volgensis***

Taxonomic treatment of *Adonis* in Kazakhstan

Adonis apennina L., Sp. Pl. 1: 548 (1753)

Fig. 3

≡ *Adonanthe apennina* (L.) Sennikov in Novosti Sist. Vyssh. Rast. 31: 83 (1998)
≡ *Chrysocyathus apenninus* (L.) Sennikov in Fl. Vostochnoĭ Evropy 10: 179 (2001)

Type. Sweden. [*Adonis*] "3. *apeninna*. H[ortus] U[psalensis]", cult. *Linnaeus 714.5* (lectotype LINN). [designated by Wang 1994b].

General distribution. China (Inner Mongolia, Xinjiang), Kazakhstan (Altai), Mongolia, Russia (Altai, Amur, Buryatiya, Chita, East European Russia, Irkutsk, Krasnoyarsk, North European Russia, Tuva, West Siberia, Yakutia) (POWO 2025).

Distribution in Kazakhstan. Altai, Tarbagatai.

Habitat and ecology. This species grows in open forests, among shrubs, along forest edges, and in dry meadows at altitudes of 700–1100 metres above sea level.

Conservation status. The estimated EOO is 62,605 km^2 and estimated AOO is 84 km^2. Therefore, the conservation status of *A. apennina* has been assessed vulnerable [VU B2a(ii)]. Therefore, we consider it necessary to include this species in the next edition of the Red Data Book of Kazakhstan.

Phenology. Flowering in May–June; fruiting in June–July.

Chromosome number. 2n = 16 (Schlangena 1976; Schrager and Malakhova 1978) and 24 (Mitrenina et al. 2021).

Notes. *Adonis apennina* was originally described by Linnaeus (1753) based on specimens from Siberia. He distinguished it from *A. vernalis* based on several characteristics

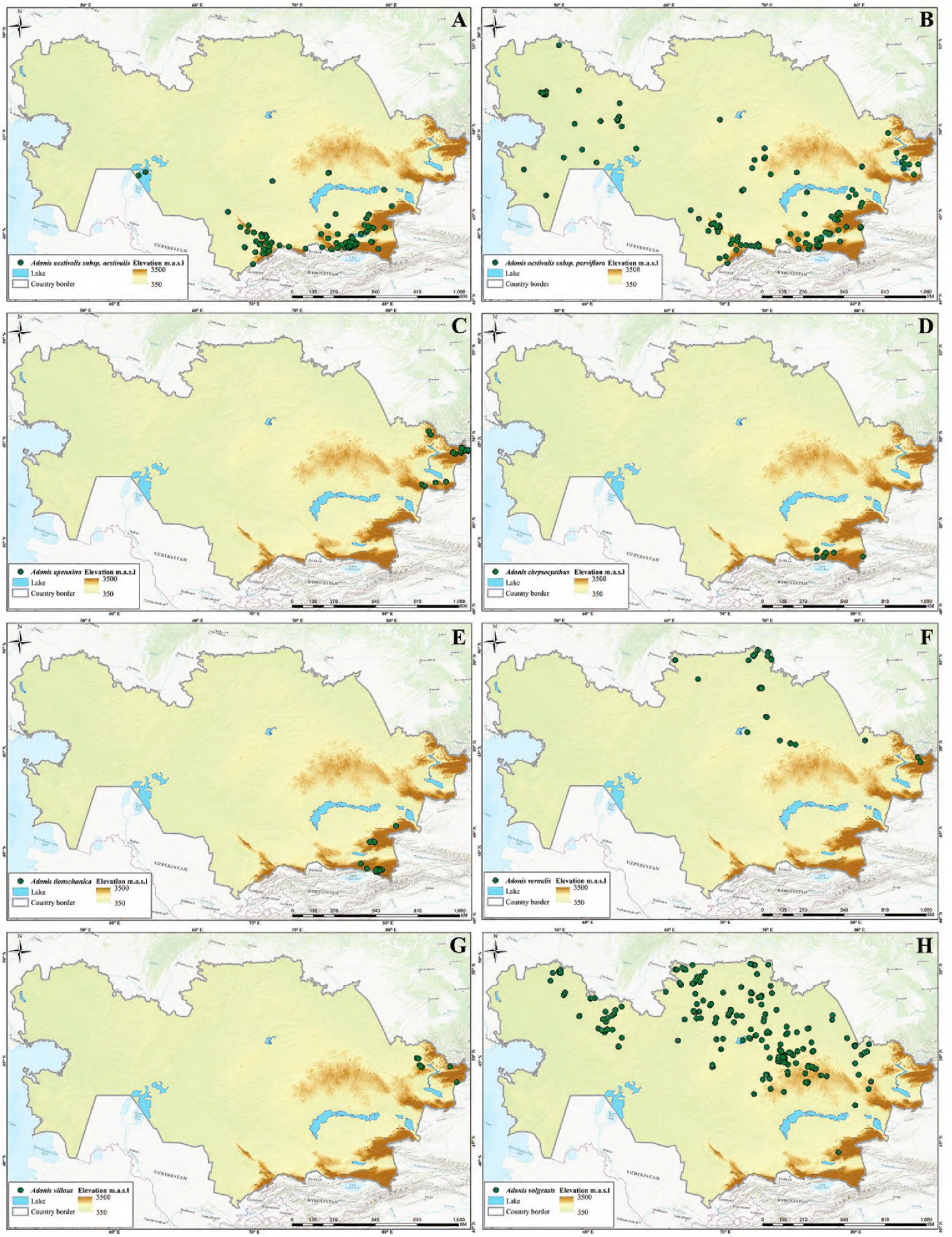

Figure 2. Distribution map of *Adonis* in Kazakhstan **A** *A. aestivalis* subsp. *aestivalis* **B** *A. aestivalis* subsp. *parviflora* **C** *A. apennina* **D** *A. chrysocyathus* **E** *A. tianschanica* **F** *A. vernalis* **G** *A. villosa* **H** *A. volgensis*.

such as stem branching in the upper part, longer pedicels, glabrous sepals, obovate petals, and a summerflowering period. The taxonomic status of *A. sibirica* (Patrin ex DC.) Ledeb. has long been debated and was initially described as *A. vernalis* var. *sibirica* Patrin ex DC. (De Candolle 1818). However, although it was later elevated to species,

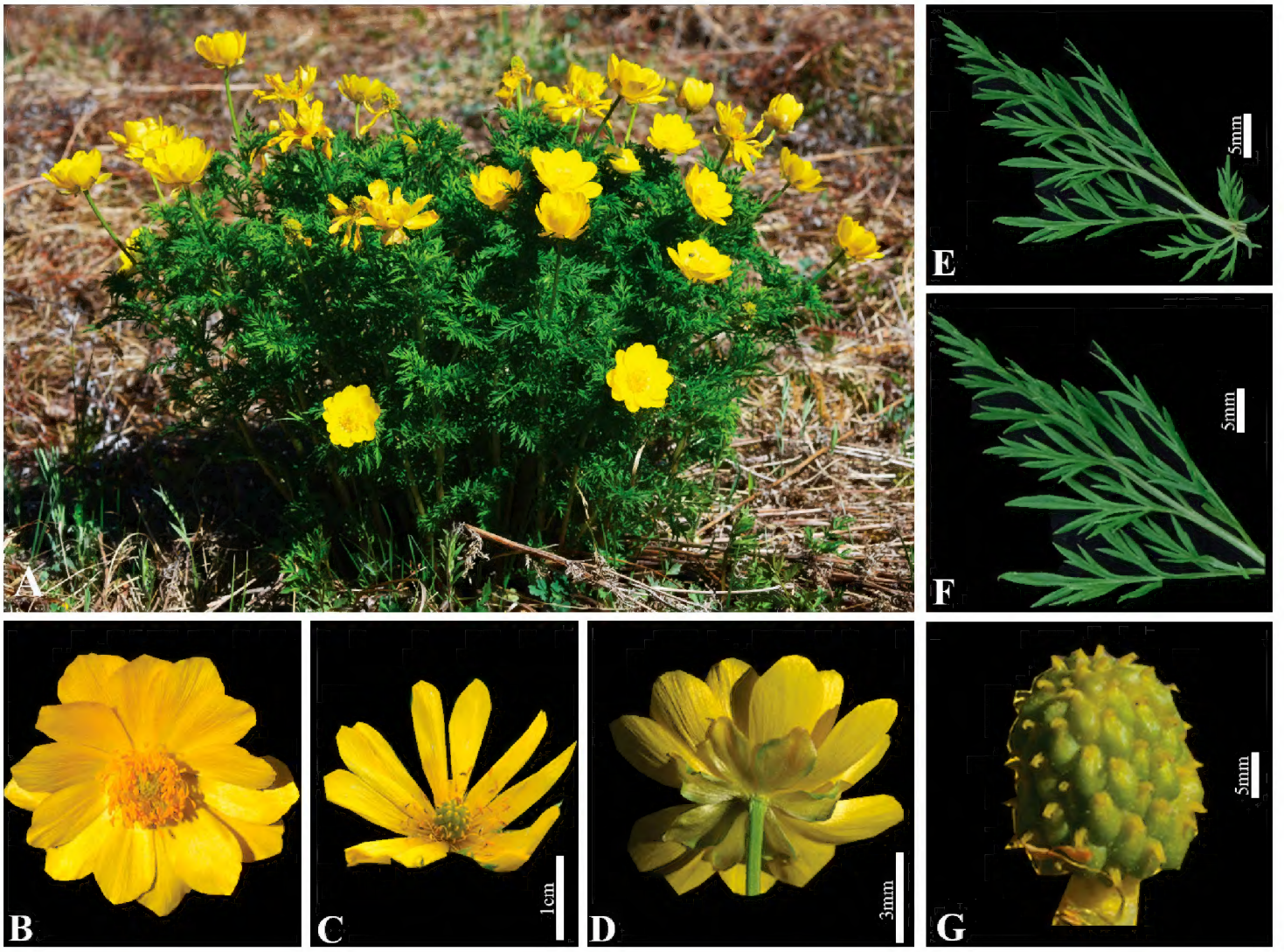

Figure 3. *Adonis apennina* in Kazakhstan **A** general habit **B, C** flowers, front view **D** flower, dorsal view **E, F** leaves **G** aggregate fruit. (Photos by S. Baasanmunkh)

variety, and subspecies ranks (Ledebour 1824, 1830; Korzhinsky 1892), it is currently treatedas synonymous with *A. apennina* owing to their overlapping morphological characteristics (Wang 1994b; Son 2015). Chrtěk and Slavíková (1978) proposed the separation of this group under the genus *Adonanthe* Spach, but later works, including Sennikov (1998), favored maintaining *A. apennina* within *Adonis*. Phylogenetic data from recent years confirmed that *A. apennina* belongs to *Adonis*, specifically to the subgenus *Adonanthe* (Ling et al. 2025). This species is distributed across northeastern European Russia, Siberia, the Russian Far East, Central Asia, Mongolia, and China (Poschkurlat 2000). The occurrence of this species in the Apennines is most likely due to a misreading of Menzelius' notes by Linnaeus (Sennikov 1998). According to Wang (1994a), *A. apennina* is classified under the subg. *Adonanthe* sect. *Adonanthe* W.T.Wang ser. *Apenninae* Bobr.

Specimens examined. Altai: Near the village of Katon-Karagay, Sarymsakty Ridge, Ushkungey Tract, 13 Aug 1972, Pimenov et al. 380 (MW 0112971!); near the village of Altayskaya [Katon-Karagay], 15 Aug 1932, Voronov 701 (MW 0112972!); same location, 27 Jul 1899, Ladygin, s.n. (LE!); near the village of Arshaty, Tautekeli River Valley, 1 Jun 2021, Bolbotov s.n. (ALTB!); Bukhtarma River Valley, 2 km upstream from the mouth of the Sarygul-Bulak River, 5th bridge, 18 Jun 2020, Bolbotov s.n. (ALTB!); right bank of the Bukhtarma River Valley, Kainar Mountains, 4 Jun

1999, Kudabaeva s.n. (AA!); left bank of the Bukhtarma River, along the road to Rakhmanovskie Klyuchi, 30 May 1999, Kudabaeva s.n. (AA!); Southern Altai Ridge, left bank of the Kara-Kaba River, 3 Jul 1987, Ivashchenko s.n. (AA!); Southern Altai Ridge, upper reaches of the Kara-Kaba River, 30 Jun 1987, Isaev s.n. (AA!); Southern Altai Ridge, 20 Aug 1986, Ivashchenko s.n. (AA!); Southern Altai Ridge, 3 km east of the Pronikha River, 27 Jul 1987, Ivashchenko and Isaev s.n. (AA!); Sarymsakty Ridge, Tekeli River Valley, 2 Aug 1985, Bialieva s.n. (AA!); Southern Altai, Chindagatuy Rivers, 28 Jul 1986, Ivashchenko s.n. (AA!); Western Altai, northwest of Ridder, near Mount Golukha, 31 Jul 1947, Polyakov s.n. (AA!); near Ridder, Krestovaya Mountains, 26 Jun 1937, Kuznetsov s.n. (AA!); Altai, Bukhtarma Basin, Uryl River near the village of Uryl, Bakanaz [Bakanas] Tract, 1 Jun 1955, Razlivalov s.n. (AA!); Altai, Sarymsakty Mountains, Dzholar Rivers, 15 Jun 1910, Reznichenko 144 (LE!); Altai Mountains, Dzholar River Valley, near Sarymsakty Mountain, 13 Jun 1910, Reznichenko s.n. 75 (LE!). **Tarbagatai:** Near the village of Tarbagatai, Manrak Ridge, Tuyuk Gorge, 26 May 1981, Rakityanskaya s.n. (AA!); Tarbagatai Ridge, 15 Jul 1948, Stepanova s.n. (AA!); Tarbagatai Ridge, northern slope 5 km north of Khabar-Asu Pass, 15 Aug 1948, Stepanova s.n. (AA!); Tarbagatai Ridge near Tas-Beit-Kuduk, 12 Jul 1914, Shishkin and Genina s.n. (LE!).

Adonis aestivalis L. subsp. *aestivalis* Sp. Pl., ed. 2. 1: 771 (1762).

Type. [*Adonis*] "1. *aestivalis*", *Linnaeus 714.1* (lectotype LINN). [designated by Shlangena 1975].

General distribution. Afghanistan, Algeria, Austria, Belarus, Bulgaria, Corse, Cyprus, East European Russia, France, Germany, Greece, Hungary, Iran, Iraq, Italy, Krym, Morocco, Nepal, North Caucasus, Pakistan, Palestine, Romania, South European Russia, Spain, Switzerland, Tadzhikistan, Transcaucasus, Turkey, Turkmenistan, Ukraine, West Himalaya, Xinjiang, Yugoslavia (POWO 2025).

Distribution in Kazakhstan. Aral region, Betpak-Dala, Balkhash-Alakol, Dzungarian Alatau, Trans-Ili Kungey Alatau, Chu-Ili range, Kyrgyz Alatau, Karatau, Western Tian Shan.

Habitat and ecology. This species grows on weeds in crops and livestock resting areas.

Conservation status. The conservation status of this species is not assessed because it is a non-native species in Central Asia.

Phenology. Flowering in April–June; fruiting in May–July.

Chromosome number. 2n = 32 (Shlangena 1976; Rice et al. 2015).

Notes. According to Wang (1994a) *A. aestivalis* subsp. *aestivalis* is classified under the subg. *Adonis* sect. *Lophocarpa* W.T.Wang ser. Aestivales W.T.Wang. Shlangena (1975) reported that this species exhibits variability within a single population: specimens with weak pubescence (long sparse hairs) on the lower part of the stem and at the base of the leaf petiole can be found, and the fruits may be either wrinkled or nearly smooth. The length of the beak also varies significantly (from 1–2.5 mm).. Previously, *A. bienertii*

Butkov ex Riedl (Riedl 1963; Schlangena 1975) was cited as an independent species in the flora of Central Asia and the Caucasus, but analysis of its diagnostic characters (branching of the basal part of shoots, tuberculate-rough surface of fruits, thin (almost transparent) upper prong, pubescent sepals, shortened, weakly dissected leaf lamina) shows that they are located within the variability of *A. aestivalis* (Luferov 1999). *A. aestivalis* originated from the Mediterranean Basin and western Asia (Meyer et al. 2015). According to Meusel (1943), it is present in Middle Asia, reaching the shores of the Black Irtysh. However, Butkov (1953) believed that it is not present in this region, where *A. aestivalis* subsp. *parviflora* is widespread (Poschkurlat 2000). Subsequently, Gamayunova (1961) confirms the presence of *A. aestivalis* (= *A. aestivalis* subsp. *aestivalis*) in the flora of Kazakhstan. According to this work *A. aestivalis* was found in the Aral region, Trans-Ili Kungey Alatau, Chu-Ili range (Gamayunova 1961). According to our research, based on the study of morphological features in the territory of Kazakhstan grow two subspecies.

Specimens examined. Aral region: Island Barsakelmes, 6 May 1946, Platonov s.n. (AA!); same location, 1935, Nazarov s.n. (AA!); Kulandy Peninsula, Akmechet, 8 May 1957, Maleev 609 (LE!). **Betpak-Dala:** Betpak-Dala Desert, dry watercourse, 17 May 2010, Kupriyanov and Mihajlov s.n. (KUZ!). **Balkhash-Alakol:** Iliysk Station [Konaev], 9 May 1934, Gel'd s.n. (AA!). **Dzungarian Alatau:** Keytyn Tract, 13 June 1937, Rubtzov s.n. (AA!); near May-Tjube [May-Tobe] Station, 14 May 1937, Kubanskaya s.n. (AA!); hill 1107 m near the highway close to Krasnogorovka [Karymsak], 25 May 1959, Goloskokov s.n. (AA!). **Trans-Ili Kungey Alatau:** Right bank of the Almatinka River, 28 May 1928, Lipschitz 473 (LE!); near Talgar, 11 May 1994, Danilov s.n. (AA!); Talgar River, 25 May 1925, Popov s.n. (AA!); 10 km north of Chemolgan [Zhibek Zholy], 11 May 2003, Korolyuk and Hrustaleva s.n. (KUZ!); Poganka [Kerenkulak] River Gorge, 1 June 1936, Shishkin s.n. (AA!); near the Kastek River Gorge, near Djildy-Say, 24 May 1936, Linczevsky s.n. (AA!); Kastek Gorge, 25 May 1936, Dmitrieva s.n. (AA!); 11 km east of Almaty, 22 May 1950, Polyakov s.n. (AA!); Burundai Tract, 25 May 1931, Muhlya s.n. (AA!); Syugaty City, 14 June 1937, Gorbunova s.n. (AA!); Syugaty Mountains, 10 June 1963, Goloskokov s.n. (AA!); Almaty, Botanical Garden, 25 May 1933, Gel'd s.n. (AA!); Almaty, 17 May 1936, Shishkin s.n. (AA!); near Verny [Almaty], 30 April 1889, Killoman s.n. (LE!); near Verny [Almaty], steppe between the Kaskelen and Aksay Rivers, 7 May 1902, Sapozhnikov s.n. (LE!); hills south of Almaty, 18 May 1928, Lipschitz 24 (LE!; MW 0831928!); near [Almaty], 6 June 1911, Skorobogat'ko 77 (LE!); near the mountains of Verny [Almaty], 15 June 1911, Skorobogat'ko 78 (LE!); near Issyk [Esik], 6 July 1968, Baitenov s.n. (NUR!); before Uzunagach [Uzynagash] along the Almaty-Bishkek highway, 18 May 2018, Bilibayeva and Zhumadilova 2957 (NUR!). **Chu-Ili Range:** Upper reaches of the Kopaly River, 9 May 2003, Korolyuk and Hrustaleva s.n. (KUZ!). **Kyrgyz Alatau:** Near Taraz, 11 April 2022, Nurhanov; 20 km east of Merke settlement, 5 May 1958, Gubanov 503 (LE!); ephemeral desert between Lugovoy and Dzhambul [Taraz], 15 May 1963, Goloskokov s.n. (LE!). **Karatau:** Intermountain valley in the upper reaches of Chimbulak, 22 June 1931, Kornilova s.n. (AA!); near Araltobe, 26 May 1963, Goloskokov s.n. (AA!; LE!); near Minzhilke [Mynzhylky], 8 May 1939, Pavlov s.n. (AA!); east of Lake Biylikul' [Bilikol], 27 May 1930, Volkova s.n. (AA!); slope

of Mount Kara-Murun, 21 April 1973, (NUR!); Ikan-Su River Gorge, 27 April 2003, Kupriyanov s.n. (KUZ!); near Terekty village, Borolday Mountains, 23 April 2015, Kupriyanov s.n. (KUZ!); Borolday Gorge, 16 May 2014, Kupriyanov s.n. (KUZ!). **Western Tian Shan:** Near Tyulkubas, Zhanzakovo [Zhanuzakov] village, 26 April 2018, Epiktetov (personal observation); near Kazygurt, Kakpak village, 22 May 1922, Korovin s.n.; Aksu-Zhabagly, near Aksu Canyon, 30 May 1942, Karmysheva s.n. (AA!).

***Adonis aestivalis* subsp. *parviflora* (DC.) N.Busch, Fl. Caucas. Crit. 3(3): 201 (1903).**

Fig. 4

Type. Kazakhstan. "Ad ripas fluvii Rhymni prope lacum salsum Inderiensem. Petala paliddecoccinea, in sicco albida" (isotype LE). [designated by Shlangena 1975].

General distribution. Armenia, China (N-Xinjiang), Georgia (Caucasus), Kazakhstan, Kyrgyzstan, Turkmenistan, Uzbekistan; Northern Caucasus; Turkey; SW-Tibet (Hassler 1994–2025).

Distribution in Kazakhstan. Caspian, Aktobe, Mugojary, Emba, Turgai, Western Upland, Eastern Upland, Zaysan, Northern Ustyurt, Mangyshlak, Aral, Kyzylorda, Betpak-Dala, Balkhash-Alakol, Moiynkum, Altai, Turkestan, Dzungarian Alatau, Trans-Ili Kungey Alatau, Chu-Ili Range, Kyrgyz Alatau, Karatau, Western Tian Shan.

Habitat and ecology. This species grows in wastelands, fallows, and crop fields, near livestock camps, in shady areas, and among shrub thickets on plains and foothills. This species is an indicator of soil and vegetation degradation in the desert regions of Kazakhstan(Osmonali et al. 2024).

Conservation status. The estimated EOO is 2,210,152 km^2 and estimated AOO is 476 km^2. Therefore, the conservation status of *A. aestivalis* subsp. *parviflora* has been assessed as of least concern.

Phenology. Flowering in April–May; fruiting in May–June.

Chromosome number. 2n = 32 (Shlangena 1976).

Notes. *Adonis aestivalis* subsp. *parviflora* differs from subsp. *aestivalis* by its smaller flowers (5–10(–15) mm in diameter), shorter and mostly unbranched stems (5–20 cm), and smaller achenes (2.5–4.0 mm long) (Luferov 1999). According to Wang (1994a), *A. aestivalis* subsp. *parviflora* belongs to subg. *Adonis* sect. *Lophocarpa* W.T.Wang. ser. Aestivales W.T.Wang.

Specimens examined. Aktobe: Northeast of Uil settlement, chalk hills of Akshatau, May 1969, Matyashenko s.n. (MW 0831952!). **Altai:** Near Ust-Kamenogorsk, 16 Jun 1936, Temnoev s.n. (LE!); 10 km north of Kuigan settlement, Kaznakovskaya ferry area, southern foothills of the Narym Range, southwest slope, 8 Jun 1998, Kotuhov et al. s.n. (KUZ!). **Aral Region:** Malye Barsuki, 11 May 1931, Serova s.n. (MW 0831953!); 45 km south of Chelkar [Shalqar], 30 May 1930, Gozhev et al. s.n. (LE!); Nikolay Island, western shores of Nordovaya Bay, sandy steppe Ken-Tubek [Kantubek], 6 Jul 1921, Rabkova s.n. (LE!). **Balkhash-Alakol:** 13 km east of Kabanbay station, Arzantau Mountain

Figure 4. *Adonis aestivalis* subsp. *parviflora* in Kazakhstan **A** general habitat **B** general habits **C** flower, front view **D** flower, dorsal view **E** aggregate fruit **F** leaves (Photos by S. Baasanmunkh).

vicinity, 27 May 2002, Maslova & Hrustaleva s.n. (KUZ!); Ak-Kul tract, sands between the Ili and Karatal rivers, 16 May 1930, Nikitin s.n. (LE!). **Betpak-Dala:** Central Betpak-Dala, Kok-Ashik tract, 21 May 1940, Rubtzov s.n. (AA!); Kok-Ashyk tract, hill 3 km northwest of the station, 22 May 1960, Ospanova s.n. (LE!). **Caspian Region:** Near Lake Inder, 23 May 1927, Keller s.n. (BRNU 135320!); near the Inder Mountains, gypsum sinkhole, 9 Jun 1998, Il'in & Grigor'ev s.n. (AA!); near Lake Inder, 7 May 1870, Smirnov 265 (LE!); Lake Inder, 1870, Smirnov 40 (LE!); near Lake Inder, 22 May 1870, Smirnov s.n. (LE!); near Inder, 3 Jun 1927, Il'in & Grigor'ev s.n. (LE!); right bank of the Ural River opposite Zelenyy settlement, May 1959, Soletzkij s.n. (LE!). **Chu-Ili Range:** Near middle school Kulakshino [Qulaqshyn], 23 May 1948, Pavlov s.n. (MW 0831924!). **Dzungarian Alatau:** Chulak [Shulak] Mountains, Manshasay, 31 May 1955, Goloskokov s.n. (AA!; LE!); Kerbulak, Altyn-Emel State National Nature Park, 26 Apr 2015, Epiktetov (personal observation). **Eastern Upland:** Bektauata Mountains, 7 May 2015, Teplouhov (personal observation); Songaria, Maitass Mountains, 1 Jun 1843, Schrenk s.n. (AA!); Arkarly Mountains, near Shengel'dy spring, 25 Jun 1960, Roldugin s.n. (AA!). **Emba:** Near Temirsky Uyezd, Kozha-Tugay tract, 17 May 1908, Borodin et al. 82 (LE!); between the Emba River and Ustyurt, clay plain between Chirtaly [Shyrqala] and Kopty-Kuduk [Kopkuduk], 10 Jun 1926, Rozhevitz 363 (LE!). **Karatau:** Syrdarya-Turkestan

Regional Natural Park, Karatau Range, Ayak-Sunga Valley, 31 May 2016, Kupriyanov & Kupriyanov s.n. (KUZ!). **Kyrgyz Alatau:** Foothills at the entrance to Aspara Gorge, 17 May 1984, Nelina s.n. (AA!). **Kyzylorda:** Near Perovsky Uyezd, Tar-Tugay, 8 Mar 1914, Sapozhnikov s.n. (LE!); near Tomenaryk, 7 May 1903, Berg s.n. (LE!). **Mangyshlak:** Eastern Karatau, Besshoqy Mountain, 5 May 1989, Safronova & Orlova 187 (LE!). **Moiynkum:** Moiynkum, near Akyr-Tyube station, 23 May 1931, Asshanova s.n. (MW 0831956!); near Akyr-Tyube station, sandy steppe in a depression between ridges, 24 May 1931, Igolkin 6 (LE!). **Mugojary:** Near Mugojary, Aktobe Province, Boktybay Mountain, 21 May 1927, Rusanov 94 (AA!); near the railway station Ber-Chogur, 6 May 1910, Androssov 147 (LE!); near Mugojary, Aktobe Province, between Solyanaya and Karagandy stations, 18 May 1927, Rusanov 35 (LE!); Boktybay Mountain, 21 May 1927, Rusanov 94 (LE!). **Northern Ustyurt:** Near Northern Chink of Ustyurt, 12 km east of Aksay tract, Artemisia–Salsola desert, 13 Jun 1956, Yunatov & Kuznetsov s.n. (LE!); near Tastastau Mountains, 5 May 2018, Kubanbay 6050 (NUR!). **Trans-Ili Kungey Alatau:** Right bank of the Almatinka River, 28 May 1928, Lipschitz 473 (AA!; MW 0831925!). **Turgay:** Near Bel-Kuduk ravine, 15 May 1913, Spiridonov s.n. (LE!). **Turkestan:** Near Kostuyun division, northwest of Darmino [Dermene], 12 km north of Arys station, 29 Apr 1957, Soskov s.n. (LE!). **Western Tian Shan:** Tamdy River Valley, at the exit from the Bolshoy Aktau Mountains, 31 May 1936, Chilikina s.n. (MW 0831921!).**Western Upland:** Near Ters-Akkan, 27 May 1842, Schrenk s.n. (AA!); 44 km southwest of Kiik station, bank of the Sary-Bulak River, 30 May 1966, Nikol'skaya 4151 (LE!); 11 km southeast of Karazhal settlement, 23 Jun 1968, Rachkovskaya et al. s.n. 260 (LE!); near Aktau Mountain, 8 Jun 1958, Karamysheva 5941 (LE!). **Zaysan:** Near eastern part of Zaysan Uyezd, glade near Kara-Tumsuk Mountain, 7 Jun 1903, Reznichenko s.n. (LE!); Zaysan Uyezd, Zaysan Lake shore, Topolevy Cape – Kolkora tract, 20 May 1914, Shishkin s.n. (LE!); northern shore of Zaysan Lake, near Dzhaman-Kul Lake, 8 May 1863, Potanin 10 (LE!); near Shakilmys Mountain, 14 May 2001, Kupriyanov et al. s.n. (KUZ!); Kurchum Ridge, road to Kurchum settlement, Zheltau tract, 14 Jun 2004, Kupriyanov & Manakov s.n. (KUZ!); near Ashutas Mountain, 10 May 2001, Kupriyanov et al. s.n. (KUZ!); near Karabiryuk Mountain, inter-slope depressions, 11 May 2001, Kupriyanov et al. s.n. (KUZ!).

***Adonis chrysocyathus* Hook.f. & Thomson ex Hook.f., Fl. Brit. India [J. D. Hooker] 1(1): 15 (1872)**
Fig. 5

≡ *Adonanthe chrysocyatha* (Hook.f. & Thomson) Sennikov in Novosti Sist. Vyssh. Rast. 31: 84 (1998)
≡ *Chrysocyathus falconeri* Chrtek & Slavíková in Preslia 50: 24 (1978)

Type. ***Lectotype***: India. Kashmir, Nagam, 16 July 1838 *Falconer 34* (K 000694234[digital photo!]); image of lectotype is available at https://records.data.kew.org/ (accessed on 8 July 2025). [designated here by Alibekov D.T.]

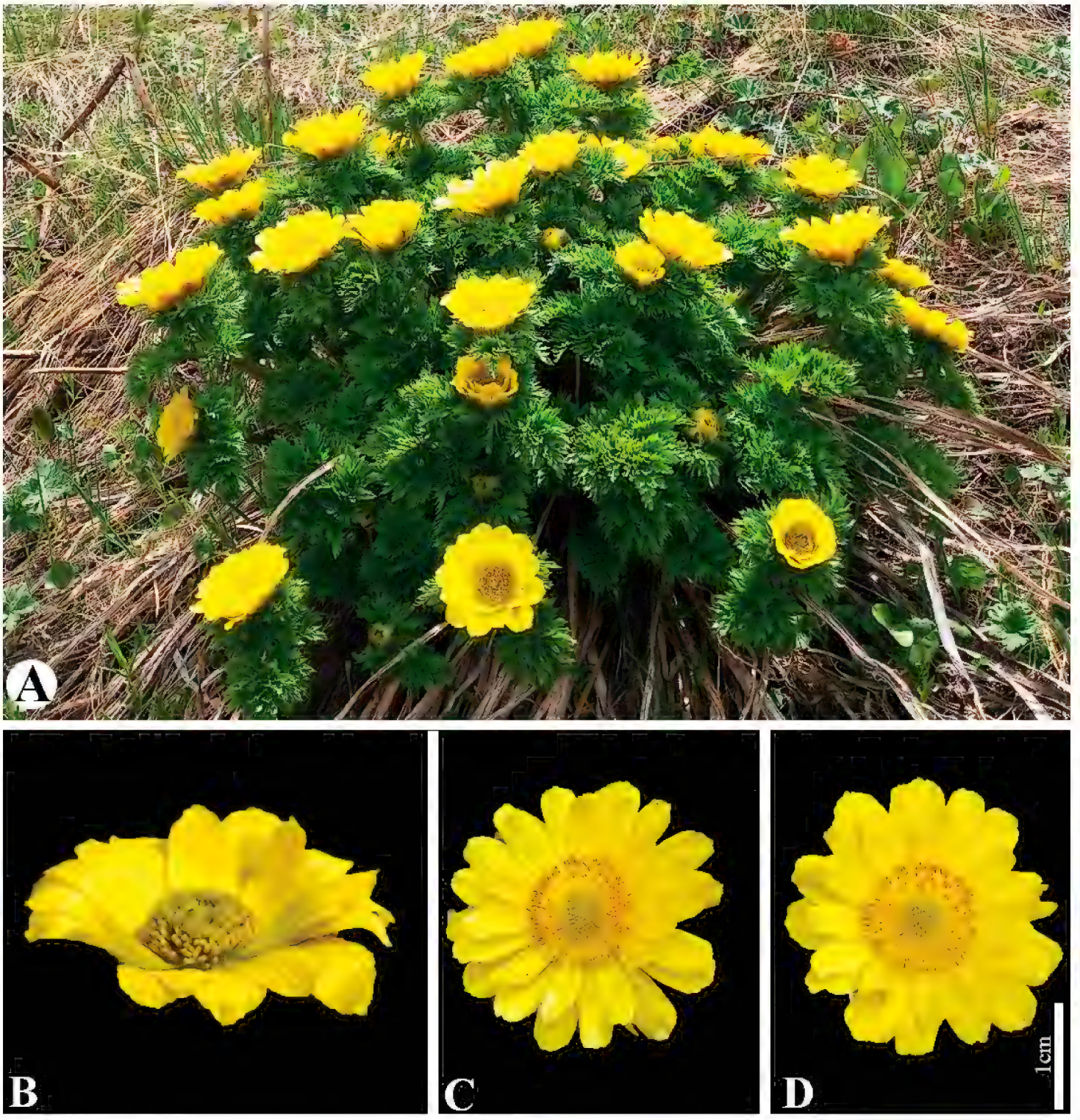

Figure 5. *Adonis chrysocyathus* in Kazakshtan **A** general habit **B–D** flowers, front view. (Photos by I. Otradnykh).

General distribution. China (Xinjiang), Kazakhstan, Kyrgyzstan, Nepal, Tajikistan, Tibet, Uzbekistan, West Himalaya (POWO 2025).

Distribution in Kazakhstan. Trans-Ili Kungey Alatau, Ketmen-Terskey Alatau.

Habitat and ecology. This species grows on fine-earth slopes and meadows near snow patches in the upper mountain belt.

Conservation status. The estimated EOO is 7,271 km^2 and estimated AOO is 32 km^2. Therefore, the conservation status of *A. chrysocyathus* has been assessed endangered [EN B2a(ii)]. In addition, this species was included in the Red Book of Kazakhstan under category III (Baitulin 2014).

Phenology. Flowering in June–July; fruiting in August.

Chromosome number. 2n = 16 (Shlangena 1976).

Notes. When searching for the type specimen of this species, we discovered that it had not yet been designated (Sennikov 2023). Wang (1994a) cited syntype K and isosyntype P as 00164137S. We chose the lectotype as per the aforementioned information, from the specimens housed at Kew (K), collected by Falconer. From the collector information given in the protologue of *A. chrysocyathus* – "Western Alpine Himalaya, in Chamba and Kashmir, *Jacquemont*; Western Tibet, Deotsu and Guge, *Strachey* and *Winterbottom*" – we found collections by V. Jacquemont from Punjab (P00164139) and Kashmir (P00164140), as well as collections by Strachey R. & Winterbottom J.E., Trollius No. 3 (K004387932). Hooker and Thomson (1855) used these specimens to construct protologue of *Adonis pyrenaica* Hook.f. & Thomson, nom. illeg. Indirectly, via a duplicate (P 00164141), we established that the specimens Strachey R. & Winterbottom, J.E., *Trollius* №3 were collected in 1843. However, lectotype K 000694234 was collected on 16 July 1838. A year later, Falconer (1839) described the genus *Chrysocyathus* Falc. from Kashmir for the first time in a letter to Dr. Royle (Chrtek and Slavíková 1979). The following year, Falconer's letter with the description of the genus was published again, without any changes (Royle 1839, Chrtek and Slavíková 1979). In 1872, Hooker and Thomson (1872) first mentioned the genus *Chrysocyathus* and used Falconer's generic name for the species epithet. This is possibly because Falconer's collections, according to the label inscription "Distributed at the Royal Gardens, Kew in 1864," only became available to them in 1864. Furthermore, this specimen (K 000694234) possesses both flowers and mature fruits, corresponding to the diagnosis "achenes not angular, turgid; style tapering, revolute". The herbarium sheet also bears the inscription *"Adonis chrysocyathus* H.f. et T. 1870"—dated two years before the species' valid publication in 1872.

According to Wang (1994a), *A. chrysocyathus* belongs to subg. *Adonanthe* (Spach) W.T.Wang sect. Ancistrocarpium (Spach) W.T.Wang. The first finds of this species were mistaken by Hooker & Thomson for *A. pyrenaica*, because specimens collected by V.V. Jacquemont and Richard Strachey & J.E. Winterbottom lacked fruits. The species was subsequently described by Hooker J.D. & Thomson T. from specimens of H. Falconer from Kashmir. Later, Chrtek and Slavikova (1978) proposed a new classification of *Adonis* L., in which the following genera were distinguished: *Adonis*, *Adonanthe* Spach, and *Chrysocyathus* Falc. *Adonis chrysocyathus* Hook.et Thoms. was selected as the type genus *Chrysocyathus*. According to this classification *A. chrysocyathus* was reclassified as *Chrysocyathus falconeri* Chrtek & Slavíková. The delimitation of the new genus *Chrysocyathus* by Chrtek and Slavikova (1978) was based on the morphology of fruits and leaves. Fruits of the genus *Chrysocyathus* are more or less glabrous, spout more or less erect, curved at the end, and all species of the genus have petiolate root leaves. According to the observation of Sennikov (1998), differences in the shape of the fruit spout are also noted among annuals, where they are the only completely reliable diagnostic characters. Furthermore, the difference in shoot structure between the perennial genera *Adonanthe* and *Chrysocyathus* cannot serve as a basis for separation of the genus *Chrysocyathus* and all perennial species form a separate genus with the priority name

Adonanthe (Sennikov 1998). According to Sennikov's classification of *Chrysocyathus falconeri* a new combination *Adonanthe chrysocyatha* (Hook.f. & Thomson) Sennikov is given. Nowadays, the author adheres to and uses this combination in his work (Sennikov and Tojibaev 2021). The first finds of this species in Central Asia were described as *A. margaritae* Butkov (Butkov 1934).

Specimens examined. Ketmen-Terskey Alatau. Near the Tien Shan, Ketmen Ridge, Karatau Mountains, upper reaches of the Sumbe River, 19 Jul 1962, Arystangaliev s.n. (AA!); near the Tien Shan, Ketmen Ridge, Trekh Shcheley Tract, 19 Jul 1963, Arystangaliev s.n. (AA!; LE!). **Trans-Ili Kungey Alatau:** Near the Vostochny Talgar River, 14 Jun 1936, Bykov s.n. (AA!); near the Issyk River, upper reaches of the eastern ravines (on the pass to Turgensky Tesken-su), 14 Jul 1937, Popov s.n. (AA!; LE!); near the basin of the Karga-Uldy [Kyrgauyldy] River (interfluve of Aksay and Kaskelen), 5 Jul 1936, Goloskokov s.n. (AA!); near Pryamaya Shchel, 30 Jun 1936, Popov s.n. (AA!).

***Adonis tianschanica* (Adolf) Lipsch. ex Bobrov, Fl. URSS 7: 531 (1937)**
Fig. 6

≡ *Adonanthe tianschanica* (Adolf) Chrtek & Slavíková in Preslia 50: 24 (1978)
≡ *Adonis turkestanica* var. *tianschanica* Adolf in Trudy Prikl. Bot. 23: 328 (1929–1930 publ. 1930)
≡ *Chrysocyathus tianshanicus* (Adolf) Holub in Preslia 70: 103 (1998)

Type. Kazakhstan. Dzharkent, 31 May 1910, *Michelson 852* (Lectotype LE01010373). [designated by L. Simonovicz].

General distribution. China (Xinjiang), Kazakhstan and Kyrgyzstan (POWO 2025).

Distribution in Kazakhstan. Dzungarian Alatau, Trans-Ili Kungey Alatau, Ketmen-Terskey Alatau.

Habitat and ecology. This species grows on steppe slopes and subalpine meadows in the upper mountain belt.

Conservation status. The estimated EOO is 32,636 km^2 and estimated AOO is 64 km^2. Therefore, the conservation status of *A. tianschanica* has been assessed near threatened. It is included in the Red Book of Kazakhstan under category III (Baitulin 2014).

Phenology. Flowering in May–June; fruiting in June–July.

Chromosome number. 2n = 16 (Shlangena 1976; Rice et al. 2015).

Notes. Based on the classification introduced by Wang (1994a) *A. tianschanica* belongs to subg. *Adonanthe* (Spach) W.T.Wang sect. *Adonanthe* W.T.Wang ser. *Apenninae* Bobr. Adolf (1930) initially described the taxon as *A. turkestanica* var. *tianschanicus* Adolf), based on specimens collected from the Dzharkent region of Kazakhstan (*Michelson 852*, LE). It was later ranked as a distinct species by Bobrov (1937). Examination of specimens of *A. turkestanica* and *A. tianschanicus* revealed that *A. tianschanicus* differs from *A. turkestanica* primarily in having mostly ascending stems that branch from the

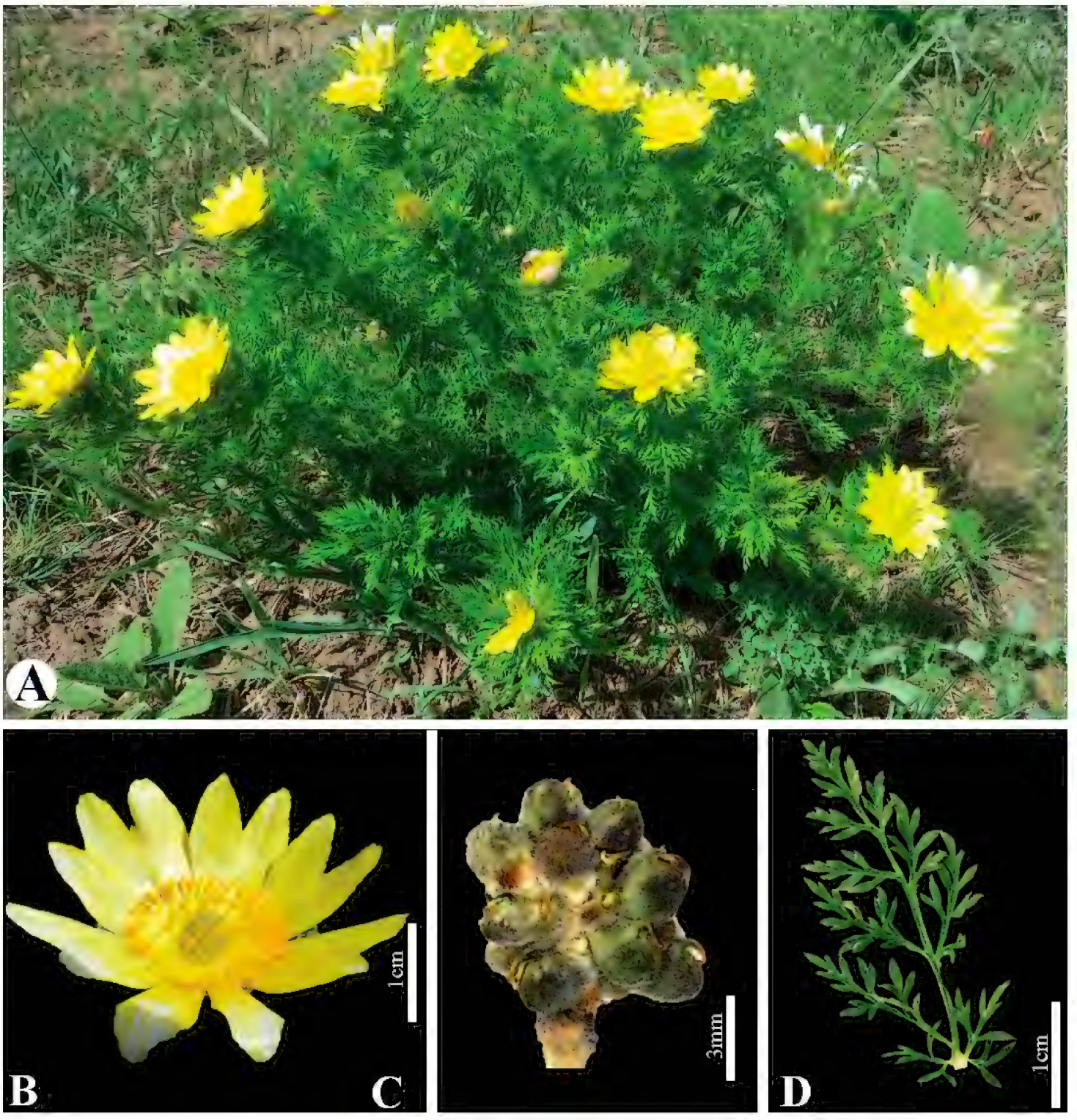

Figure 6. *Adonis tianschanica* in Kazakhstan **A** general habit **B** flower, front view **C** aggregate fruit **D** leaves. (Photos by K. Kulymbet and S. Kubentayev).

base (although some are prostrate), oblanceolate leaf segments, and smaller flowers. Sennikov (2023) combined these two taxa into one species, *Adonanthe turkestanica* (Korsh.) Chrtek & Sláviková, according to priority, but previously synonymized *A. leiosepala* Butkov with *Adonanthe tianschanica* (Adolf) Chrtek et Sláviková (Sennikov and Tojibaev 2021). One reason for combining the two taxa was that, as noted by Kovalevskaya (1972), the two species do not differ in the herbarium. In addition, in 1964, L. Simonovich, when examining specimens of *A. leiosepala* Butkov from the Kyzyl-Nur Mountains, found that they were identical to *A. tianschanica*, which is distributed in Central Tien-Shan (Evdokimov 1970). Moreover, the previously cited facts about the independence of the three species cannot be considered sufficient, as Evdokimov (1970) justified

their independence by pointing out the differences in biological activity and anatomical characteristics, such as the characteristics of the epidermis, hair size, and the presence or absence of stomata. Furthermore, the oral report of A.P. Poschkurlat on the difference between *A. lejospala* and *A. tianschanica* in habitus, ecology, and character of leaf dissection cannot provide sufficient evidence to justify the independence of the two species (Kovalevskaya 1972), as these characters cannot be reflected in a diagnostic manner. Previously, we investigated five cenopopulations of *A. tianshanica* located on the Ketmen Ridge, Dzungarian Alatau, and Terskey Alatau (Kulymbet et al. 2023). The results of this study revealed low numbers of *A. tianschanica* individuals across all studied populations, likely due to low seed productivity, the absence of vegetative regeneration, and the influence of environmental factors and anthropogenic pressures, primarily livestock grazing.

Specimens examined. Dzungarian Alatau: Kotyrkain Mountains, upper reaches of the Karagaily River, 27 May 1959, Goloskokov s.n. (AA! LE!); Dzharkent Uezd, valley of the Kar-Kora [Qarqara] River between the fairground and the Chol'-Adyr River, 22 Jun 1912, Sapozhnikov and Shishkin s.n. (LE!); along the bank of the Taldy-Bulak River, left tributary of the Kegen, 19 Jun 1912, Sapozhnikov and Shishkin s.n. (LE!); between Tsaritsynskoye [Budennovskoye] station and Kugaly station, 10 May 1912, Shishkin s.n. (LE!). **Trans-Ili Kungey Alatau:** Northeastern slopes of the mountains above the Kurmekty River, 15 May 1942, Lazarenko s.n. (AA!); near Kurmekty, southeastern slopes, 4 May 1942, Lazarenko s.n. (AA!); near the Karkara River, between the Cherganak [Shyrghanaq] River and the East Merke River, 30 Apr 1944, Kuschakewitsch s.n. (LE!); near Terskey Alatau, Turgen Gorge, 11 May 1975, Sdobnina and Poschkurlat 8 (LE!). **Ketmen-Terskey Alatau:** Basin of the Kegen River, Jun 1969, Poschkurlat s.n. (MW 0899183!); near the middle course of the Kegen River, western extremity of the Shol-Adyr Mountains, 15 Aug 1946, Rubtzov and Stepanova s.n. (AA!); steppe between Kegen and Saryzhaz, 15 May 1932, Lipschitz s.n. (MW 0832011!); valley of the Iri-su [Irsu] River, 20 Jun 1966, Boryaev s.n. (MW 0832012!); hills and foothills along the Irsu River, 3 Jun 1975, Lushpa s.n. (AA!); near the eastern extremity of the Kungey Alatau ridge, valley of the Karkara River, along the Iri-su River, 3–4 km from the ford across the Karkara River, 1 Jun 1966, Boryaev s.n. (AA!).

***Adonis vernalis* L., Sp. Pl. 1: 547 (1753)**

Fig. 7

≡ *Adonanthe vernalis* (L.) Spach in Hist. Nat. Vég. 7: 228 (1838)
≡ *Adoniastrum vernale* (L.) Schur in Verh. Naturf. Vereins Brünn 15(2): 27 (1877)
≡ *Chrysocyathus vernalis* (L.) Holub in Preslia 70: 103 (1998)

Type. Sweden. [*Adonis*] "2. *vernalis.* H[ortus] U[psalensis]", cult. *Linnaeus 714.4* (lectotype LINN). [designated by Wang 1994b].

General distribution. This species is distributed in Europe to Siberia and Caucasus (POWO 2025).

Distribution in Kazakhstan. Tobol-Ishim, Semipalatinsk pine forest, Kokchetav, Altai.

Habitat and ecology. This species grows in steppes, along the edges of steppe coppice forests, and in shrubs.

Conservation status. The estimated EOO is 685,654 km^2 and estimated AOO is 120 km^2. Therefore, the conservation status of *A. vernalis* has been assessed near threatened. Furthermore, *A. vernalis* was assessed as a species of least concern in Europe (IUCN 2024). It is included in the Red Book of Kazakhstan under category II (Baitulin 2014). *Adonis vernalis*, is a rare and protected plant (mentioned in the Convention on International Trade Endangered Species of Wild Flora and Fauna).

Phenology. Flowering in April–May; fruiting in June–July.

Chromosome number. 2n = 16 (Shlangena 1976; Mitrenina et al. 2022).

Notes. *A. vernalis* was described by Linnaeus in 1753 based on a cultivated specimen from the city of Uppsala. According to Wang (1994a), *A. vernalis* belongs to subg. *Adonanthe* (Spach) W.T.Wang sect. *Adonanthe* W.T.Wang ser. *vernales* Bobr. ex Poschk.. *A. vernalis* has the most extensive range among species of the genus *Adonis* L. (Poschkurlat 1974). Consequently, it is believed that *A. vernalis* diverged and evolved into a distinct species after migrating from the western Himalayas to Europe (Wang 1994a, 1994b; Son 2015). However, different evidence suggests that modern populations of *A. vernalis* did not originate in Asia but rather evolved in southern Europe during the Pleistocene. These findings indicate that *A. vernalis* likely migrated eastward from the sub-Mediterranean forest-steppe of southeastern Europe to the continental forest-steppe zone (Seidl et al. 2022). The results of phylogenetic analysis demonstrate a close relationship between *A. vernalis*, *A. villosa* and *A. volgensis*. These three species differ in their distribution ranges (with partial overlap) and preferred habitats (also with overlaps), suggesting possible speciation mechanisms, including geographic isolation (e.g., due to climatic fluctuations during the Pleistocene) and/or ecological speciation (Seidl et al. 2022). Furthermore, *A. vernalis* forms a sister clade with a group composed of clade IV (which includes representatives of ser. *Amurenses* Poschk. found in northeastern China, Korea, and Japan) and clade III (ser. *Apenninae* Bobr. ex Poschk., distributed in mid-western China, Mongolia, Russia, and Kazakhstan), indicating a direct relationship with these groups (Son et al. 2016). *Adonis vernalis* is a forest-steppe species. In the Kazakh Uplands, specifically on the Kokchetav Upland, there are isolated occurrences detached from the main range. Its continuous range extends much further north along the Tyumen–Ishim–Petukhovo–Petropavlovsk line and further into the southeastern part of Western Siberia (Poschkurlat 2000). Hybridization with *A. volgensis* is known to occur, forming the hybrid *Adonis* × *hybrida* G.Wolff ex Simonk. The classic habitat of *A.* × *hybrida* is Cluj-Napoca (Szénafüvek), Romania (Szabo 1977, 1978). The closest recorded locations of this hybrid to Kazakhstan are in Russia, specifically in the Volga River basin and in Altai Krai (Rakov et al. 2014; Vasjukov and Saksonov 2020; Erst et al. 2022). Given that the ranges of its parent species overlap in Kazakhstan, *A.* ×*hybrida* may potentially occur in this region. In the zonal steppe region of Eastern Europe and Western Siberia, the distribution range of *A. volgensis* (characterized by annual precipitation below 300 mm and the formation of

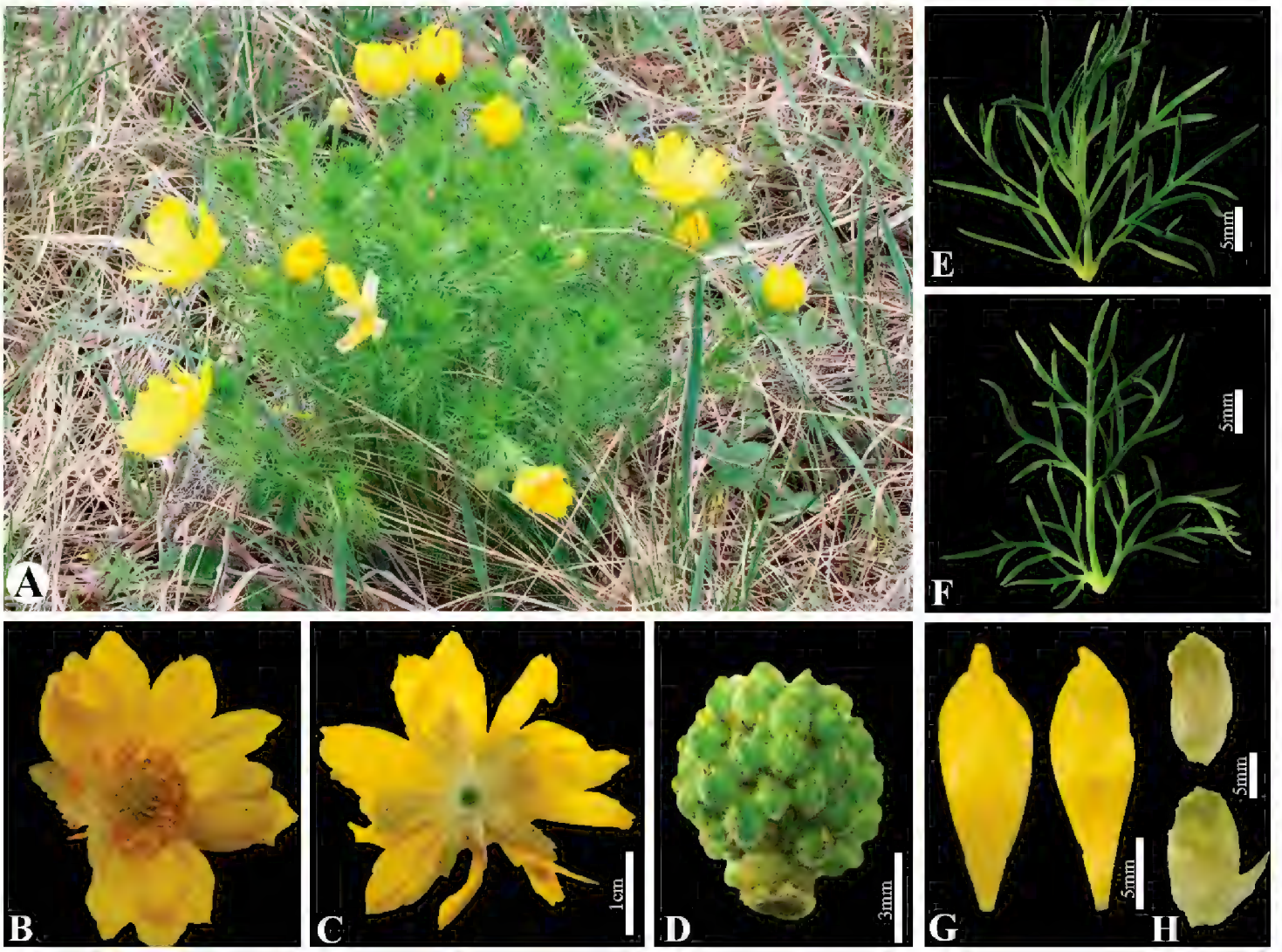

Figure 7. *Adonis vernalis* in Kazakhstan **A** general habit **B** flower, front view **C** flower, dorsal view **D** aggregate fruit **E, F** leaves **G** petals **H** calyx. (Photos by S. Kubentayev).

kastanozem soils) borders the range of *A. vernalis* (characterized by annual precipitation above 300 mm and the formation of chernozem soils) to the south (Hoffmann 1998).

Specimens examined. Altai: Near the surroundings of Bekalka village, Katon-Karagay State National Nature Park, 12 May 2020, Bolbotov (personal observation); surroundings of Altayskaya stanitsa [Qaton-Qaraghay], 1899, Ladygin s.n. (LE!); near Altayskaya station [Katon-Karagay], Narym Range, 13 Jun 1912, Kardakov 33 (LE!). **Kokchetav:** Near the settlement of Zolotoy Bor, 40th quarter of Zolotoborskoe forestry, 3 Jun 2011, Kupriyanov s.n. (KAZ 01065!; KAZ 01066!); Burabay State National Nature Park, 7 May 2019, Kubentayev 3049 (NUR!); Burabay State National Nature Park, Mirnoe forestry, quarter 101, 19 May 2021, Idrisova and Zhumagul 6487 (NUR!); beyond Arykpai, Teplaya Gorka, 21 Apr 1943, Olov s.n. (MW 0832013!). **Tobol-Ishim:** Near Meshchanskaya Grove, 8 Jun 1963, Malyutina s.n. (MW 0832017!); near Lake Pestroe, 8 Jun 1963, Malyutina s.n. (MW 0832018!); near the village of Proletarka, 12 May 2022, Knyazev s.n. (personal observation); 9 km northeast of the village of Penkovskoe, 6 Sep 1955, Borisova 4688 (LE!); 12 km from Konyukhovskiy [Konyukhovo] settlement, 27 Jul 1913, Ziles 390 (LE!); right bank of the Ishim River near Petropavlovsk, 13 May 1913, Drobov 18 (LE!); steppe near Petropavlovsk, 20 May 1913, Drobov 40 (LE!); 8 km northeast of Novonikolskoe,

14 Aug 1954, Borisova et al. 1101 (LE!); south of the village of Krasnoyarka, 25 Jun 1975, Galanina 4459 (NUR!); near Petropavlovsk, ravine slope with clay soil, 11 May 1914, Ganeshin 52 (LE!); near the 27th km of the Uritzkaya highway, near the "Energetik" children's camp, 18 May 1979, Borodulina s.n. (KSPI!); surroundings of Mikhaylovskoe forestry, 25 Apr 1971, students s.n. (KSPI!); 13 km north of Goncharovka, 13 Sep 2021, Idrisova et Urazalina 6963 (NUR!); between the villages of Goncharovka and Barnevka, 13 Sep 2021, Alibekov et al. 7162 (NUR!). **Semipalatinsk Pine Forest.** Near the Semipalatinsk district, in the forest, 1931, Dmitrieva s.n. (AA!).

***Adonis villosa* Ledeb., Ind. Hort. Dorp. Suppl. (1824).**
Fig. 8

≡ *Adonanthe villosa* (Ledeb.) Chrtek & Slavíková in Preslia 50: 24 (1978)
≡ *Adonis vernalis* var. *villosa* (Ledeb.) Regel in Bull. Soc. Imp. Naturalistes Moscou 34(II): 35 (1862)
≡ *Adonis volgensis* var. *villosa* (Ledeb.) Trautv. in Bull. Soc. Imp. Naturalistes Moscou 33(I): 63 (1860)
≡ *Chrysocyathus villosus* (Ledeb.) Holub in Preslia 70: 103 (1998)

Type. Kazakhstan. 'Riddersk Gebirge' *Ledebour s.n.* (lectotype LE 01041083). [designated by Grabovskaya-Borodina 2018].

General distribution. Altay, Kazakhstan, West Siberia (POWO 2025).

Distribution in Kazakhstan. Altai.

Habitat and ecology. This species grows on the edges of birch forests, on the slopes of hills.

Conservation status. The estimated EOO is 21,204 km^2 and estimated AOO is 32 km^2. Therefore, the conservation status of *A. villosa* has been assessed vulnerable [VU B2a(ii)]. It is included in the Red Book of Kazakhstan under category II (Baitulin 2014).

Phenology. Flowering in May–June; fruiting in June–July.

Chromosome number. 2n = 16 (Shlangena 1976; Rice et al. 2015).

Notes. Based on the classification introduced by Wang (1994a) *A. villosa* belongs to subg. *Adonanthe* sect. *Adonanthe* W.T.Wang ser. *Apenninae* Bobr. Despite the fact that *A. villosa* has a very high life expectancy (approximately 50 years, Poschkurlat 2000), this species is rare and is listed in the Red Book of the Republic of Kazakhstan (Baitulin 2014). *A. villosa* disperses its seeds through both barochory (gravity) and myrmecochory (ants) (Papina and Fotieva 2008). The main distribution area of *A. villosa* is in southwestern Siberia, where this species is usually found in meadow steppes and steppes rich in grasses (Hoffmann 1998). Its populations in this region are typically scattered and relatively small in size (Papina and Fotieva 2008). While most species of the genus *Adonis* prefer places with sufficient access to water (Heyn and Pazy 1989), species such as *A. volgensis*, *A. villosa* and *A. mongolica* Smirnov have adapted to drier conditions of mountain and mixed-grass steppes. *A. volgensis*, *A. villosa* and *A. mongolica* grow predominantly in

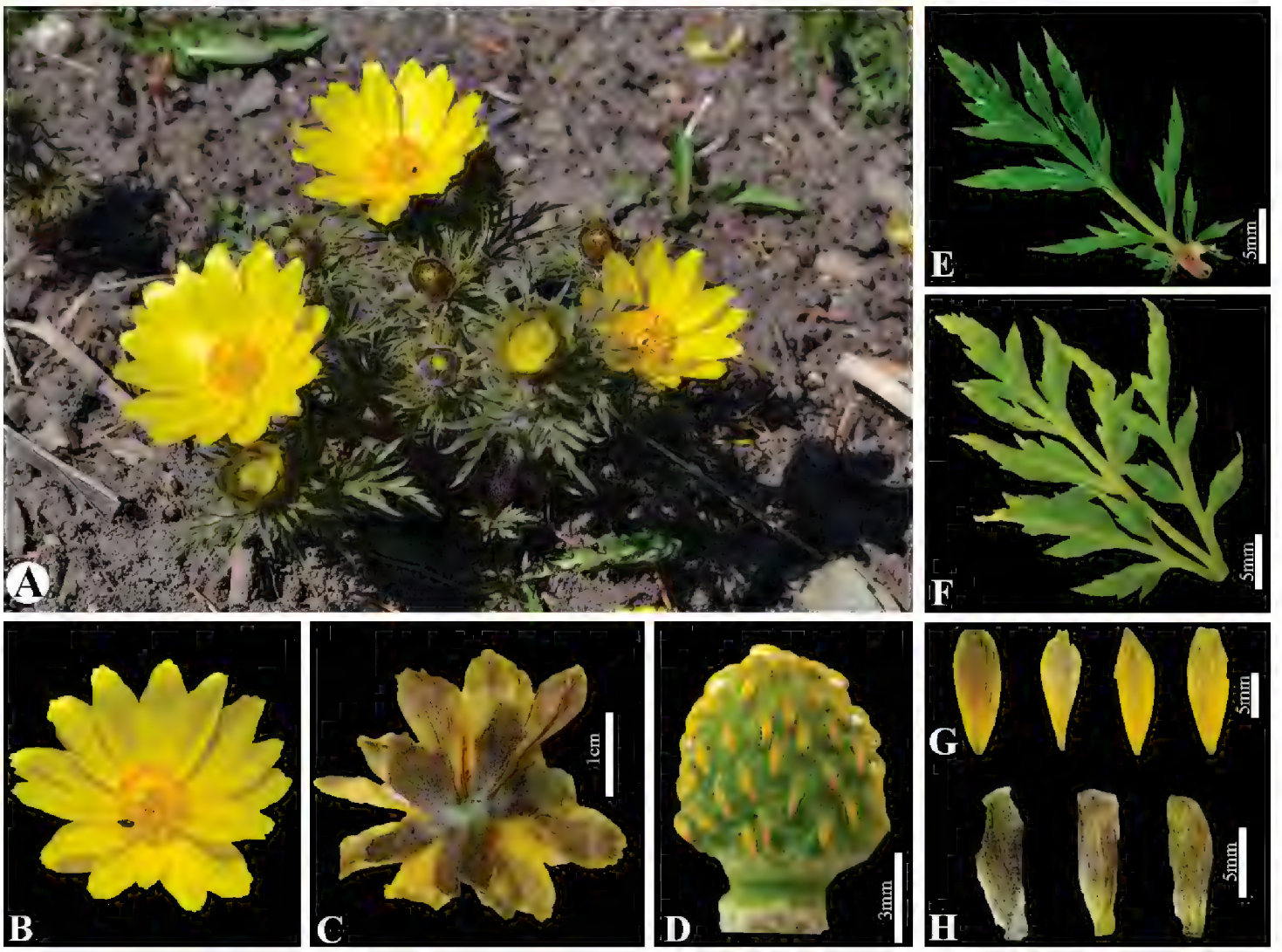

Figure 8. *Adonis villosa* in Kazakhstan **A** general habit **B** flower, front view **C** flower, dorsal view **D** aggregate fruit **E, F** leaves **G** petals **H** calyx (Photos by S. Kubentayev).

drier mountain steppes and mixed-grass steppes, and these species show signs of ecological vicariance (Hoffmann 1998; Baasanmunkh et al. 2022). Perezhogin (2015) reported the occurrence of this species in the Tobol-Ishim floristic region (Kostanay). In our opinion, this regional record is erroneous because the herbarium specimen was misidentified, as it differs morphologically from the lectotype of *A. villosa* (LE 01041083). Subsequently, *A. villosa* was not included in the list of vascular plants in the Kostanay Region (Perezhogin 2024) or in the synopsis of the family Ranunculaceae in the Tobol-Ishim and Turgay floristic regions (Sultangazina et al. 2024). Our data show that *A. villosa* is not found in Central and Northern Kazakhstan, and previous reports on its presence in these regions were based on incorrect identifications.

Specimens examined. Altai: Near the village of Skalistoye [Izghutty Aytyqov], 40 km south of Ust-Kamenogorsk, 27 Apr 1987, Smirin s.n. (MW 0113323!); near the surroundings of Leninogorsk, May 1969, Poschkurlat s.n. (MW 0113324!); near the surroundings of the village of Bekalka, Katon-Karagay State National Nature Park, 13 May 2020, Bolbotov (personal observation); near the surroundings of the settlement of Targyn, on the road to Samarka, ridge summit, 27 May 2004, Kupriyanov s.n. (KUZ!); near the Azutau Ridge, city of Mramornaya, 9 May 2001, Kupriyanov et al. s.n. (KUZ!).

***Adonis volgensis* DC., Syst. Nat. [Candolle] 1: 545 (1817).**
Fig. 9

≡ *Adonanthe volgensis* (Steven ex DC.) Chrtek & Slavíková in Preslia 50: 24 (1978)
≡ *Adonis vernalis* var. *volgensis* (Steven ex DC.) Regel in Bull. Soc. Imp. Naturalistes Moscou 34(II): 35 (1862)
≡ *Chrysocyathus volgensis* (Steven ex DC.) Holub in Preslia 70: 103 (1998)

Type. Russia. 'Ad Volgam, 1817, *Steven s.n.*', 1807, sub. nom. "*A. apennina*?" (lectotype G 00144834 (digital photo). image of the lectotype is available at http://www.ville-ge.ch/musinfo/bd/cjb/chg (accessed on 6 July 2025)). [designated by Sennikov (1988) as 'holotype'].

General distribution. Altay, Bulgaria, Central European Russia, East European Russia, Hungary, Kazakhstan, Krym, North Caucasus, Romania, South European Russia, Transcaucasus, Turkey, Ukraine, West Siberia (POWO 2025).

Distribution in Kazakhstan. Syrt, Tobol-Ishim, Semipalatinsk pine forest, Kokchetav, Caspian Region, Aktobe, Mugojary, Emba, Western Upland, Eastern Upland, Karkaraly, Betpak-Dala.

Habitat and ecology. Grows in Stipa and Stipa–Festuca steppes, occasionally along forest edges, at elevations of 400–900 m above sea level.

Conservation status. The estimated EOO is 1,405,740 km^2 and estimated AOO is 844 km^2. Therefore, the conservation status of *A. volgensis* has been assessed least concern. It is included in the Red Book of Kazakhstan under category III (Baitulin 2014). Considering its wide distribution and high frequency of occurrence, we recommend excluding this species from the Red Data Book of Kazakhstan.

Phenology. Flowering in March–April; fruiting in May.

Chromosome number. 2n = 16 (Shlangena 1976; Mitrenina et al. 2022).

Notes. This species differs from *A. vernalis* by its broader, more basally wrapped leaf lobes and smaller pale yellow flowers (Bobrov 1937). Some researchers, particularly Komarov (1944), considered *A. volgensis* to be merely a geographical race of *A. vernalis* (Melnyk and Parubok 2004). However, the results of phylogenetic analysis demonstrate a close relationship between *A. vernalis* and *A. volgensis* (Seidl et al. 2022; Conti et al. 2023). Based on the classification introduced by Wang (1994a), *A. volgensis* belongs to subg. *Adonanthe* sect. *Adonanthe* W.T.Wang ser. *vernales* Bobr. ex Poschk. In 2023, a new species *A. fucensis* F.Conti & Bartolucci, was described from the Central Apennines. The central Italian *A. fucensis* accession (A1252) is also closely related to *A. volgensis* and *A. vernalis* within the monophyletic group of *A.* sect. *Adonanthe* ser. Vernales (Conti et al. 2023). It is distributed across Central, Southeastern, and Eastern Europe, as well as Western and Central Asia (including Kazakhstan) and the northern regions of Turkey and Iran (Luferov 2020).

Specimens examined. Aktobe: Near the vicinity of the village of Akrab, chalk ridge Ishkargantau, Karasay area, 7 Jul 1965, Tscherkassova s.n. (MW 0832023!); near the chalk ridge Ishkargantau, Suyk-Bulak area, 18 Jun 1962, Tscherkassova s.n. (LE!);

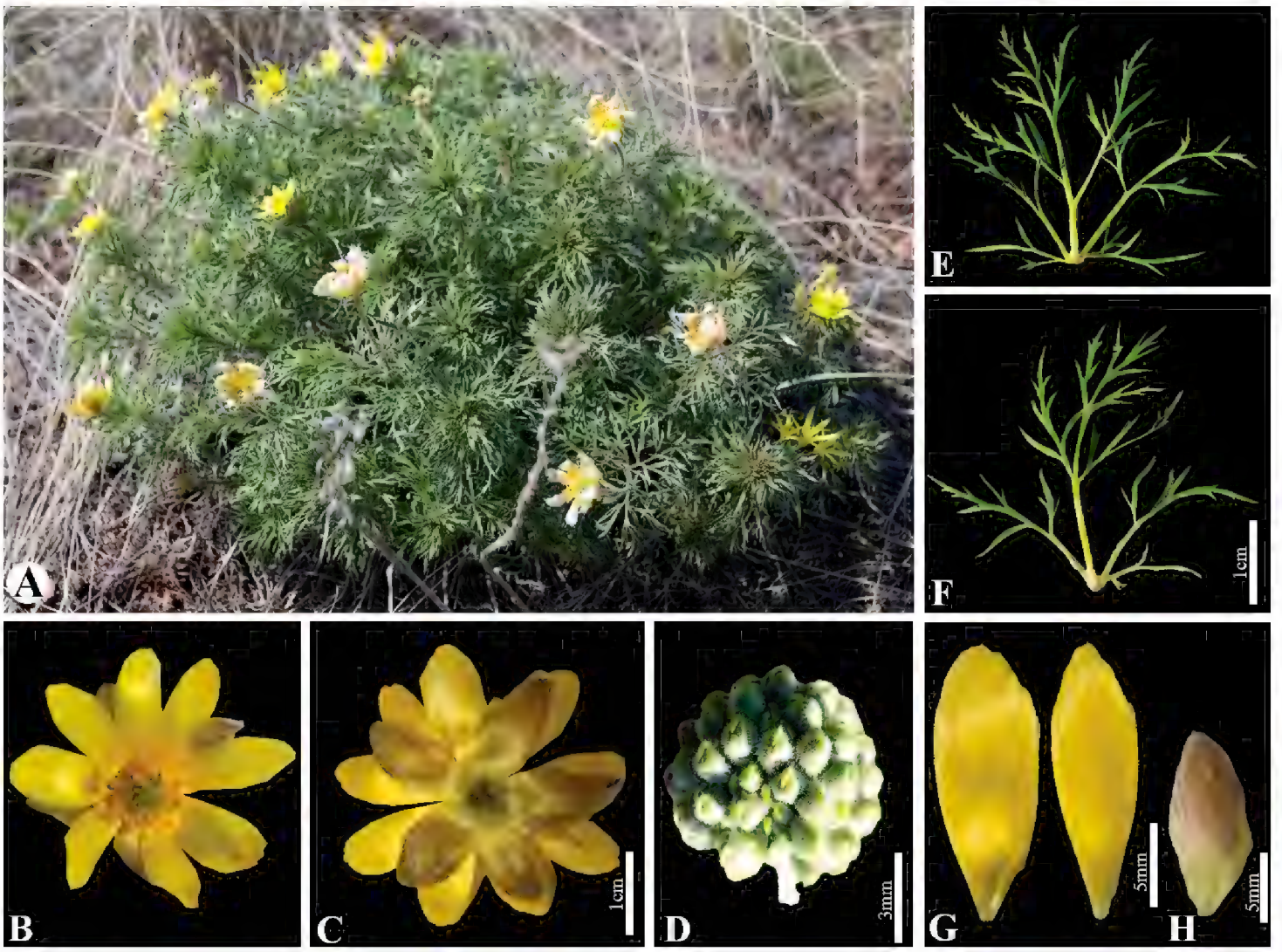

Figure 9. *Adonis volgensis* in Kazakhstan **A** general habit **B** flower, front view **C** flower, dorsal view **D** aggregate fruit **E, F** leaves **G** petals **H** calyx. (Photos by S. Kubentayev).

6 km northeast of Akrab village, 2 May 2019, Kupriyanov s.n. (KUZ!); 20 km west of Akrab village, chalk hills, 2 May 2019, Kupriyanov s.n. (KUZ!); 50 km north of the city of Temir, near the Yenbek kolkhoz, 7 Jul 1964, Tscherkassova s.n. (MW 0832026!; LE!); northeast of Uil settlement, chalk upland Akshatau, 19 Jun 1965, Tscherkassova s.n. (MW 0832027!); near the vicinity of Akshatau village, 3 May 2019, Kupriyanov s.n. (KUZ!); near the floodplain of the Butak River, 1 May 1991, Ajpeisova s.n. (AA!); near Aktobe Province, the Khobda River basin, Kenisar-Mola, watershed between Kara Khobda and Sary Khobda, 27 Jul 1926, Il'in and Avramchik 160 (LE!); foothills of the Mugodzhar Mountains in the Kargalinskoye Reservoir area, 6 May 2019, Kupriyanov s.n. (KUZ!); floodplain of the Kargala River (in the Kargalinskoye Reservoir area), 5 May 2019, Kupriyanov s.n. (KUZ!); near Temir, Ilek station, 24 Apr 1913, Spiridonov s.n. (LE!); near the Temir zonal experimental station, close to Dzhurun railway station, 12 May 1933, Voronov s.n. (MW 0832028!). **Betpak-Dala:** Intermontane plain 10 km south of the Koktas River, 30 Apr 1957, Karamysheva and Yunatov 191 (LE!). **Caspian Region:** Near Ural District, Zhambeytinsky District, 9 May 1930, Dmitrieva s.n. (AA!); valley of the Utva [Ulenty] River, 20 Jun 1927, Zhezhel' and Rozhevitz s.n. (LE!). **Eastern Upland:** Near Mount Kyzyl-Rai, headwaters of the Izbushke [Zhinishke] River, 15 Jun 1960, Denisova s.n. (MW 0832029!); near Arkat, 15 Apr 1902,

Sapozhnikov s.n. (LE!); near Semipalatinsk Uyezd, between Bet-Kuduk and Tas-Kuduk springs, 7 May 1914, Kosinsky 9 (LE!); at the foot of the Dzhaman-Bish-Cheku Mountains, 8 Jun 1928, Il'in and Heinrichson 32 (LE!); slopes of Mount Aksoran, rocky gravelly soil, 28 Jun 1998, Mikhailov 5235 (NUR!); valley of the Kokpektinka River, upper reaches from Mikhaylovskaya station to Tomar steppe area, 20 Jun 1914, Sapozhnikov and Genina s.n. (LE!); near Karaoba Hills, 9 Jul 1890, Korzhinsky s.n. (LE!); near Karkaraly Uyezd, Kumadyr area on saline soils, 19 Jul 1890, Korzhinsky s.n. (LE!). **Emba:** Near Aktobe Province, interfluve of the Uil and Emba Rivers, ascent to the Turkestan watershed between the Uil and Temir Rivers, 28 May 1926, Rozhevitz et al. s.n. (AA!); near Temir Uyezd, meadowland along the bottom of the Turkestan ravine, 4 km from the city of Temir, 20 Apr 1908, Bogdan s.n. (LE!); near Aktobe Province, interfluve of the Uil and Emba Rivers, 4 versts northeast of Temir, 19 May 1926, Rozhevitz 62 (LE!); Aktobe Province, interfluve of the Uil and Emba Rivers, 31 May 1926, Knorring 92 (LE!). **Irtysh:** 3 km south of Demyanovka Village, 17 Jun 1955, Tzvelev et al. 272 (LE!); 40 km west of Shcherbakty, 20 May 1955, Tzvelev et al. 57 (LE!); on the road from Kzyl-Tu State Farm to Kuzbass State Farm in feather grass-fescue steppe, 27 May 1955, Isachenko et al. 2557 (LE!). **Karkaraly:** Northeast of Zhel'tau settlement, 15 May 1914, Kucherovskaya 1631 (LE!); Bayanaul National Park, Bayanaul Mountains, vicinity of Mount Auliet, 26 May 2007, Kupriyanov et al. s.n. (KUZ!); along the road Zhanatilek-Pobeda, Sadik wintering area, 28 May 2007, Kupriyanov et al. s.n. (KUZ!); near Karkaraly Uyezd, Kent and Karkaraly Mountains, 15 Apr 1910, Kucherovskaya 1831 (LE!); Songaria, in montibus Karkaraly, Jun 1843, Schrenk s.n. (AA!). **Kokchetav:** Near the city of Kokshetau, along the Kokshetau-Zerenda highway, 26 May 2020, Kubentayev 5934 (NUR!); western and southern shores of Maloye Chebachye Lake, 29 Apr 1902, Ignatov and Piotrovsky 5 (LE!); 2 km west of Kokchetav, 26 Apr 1956, Isachenko et al. 27 (LE!); near the village of Krasny Gornyak, 12 Apr 2019, Kubentayev s.n. (LE!); 8 km south of Kokchetav, northeastern slope of "Galchevaya Mountain", 24 May 1955, Isachenko et al. 2513 (LE!); near the Astana-Shchuchinsk highway, vicinity of Enbek Village, 7 May 2019, Kubentayev 6658 (NUR 6658!); Borovskoy Forest, vicinity of Bulandy Village, pine forest, Burabay National Park, 89th quarter of Bulandy Forestry, 10 Jun 2011, Kupriyanov s.n. (KUZ!); near the village of Shortandy, Western Department, 26 Jun 1992, Zemlyakova s.n. (KUZ!). **Mugojary:** Near the Ber-Chogur coal mines, 29 Jul 1921, Korovin s.n. (MW 0832025!; LE!); near Irgiz Uyezd, Mugodzhar Mountains, dry meadow near Berchogur [Birshoghyr], 6 May 1910, Androssov 147 (LE!); valley of the Kundyzdy River, 5 Jul 1927, Rusanov 664 (LE!). **Semipalatinsk Pine Forest:** Near Kara-Murza Cord, Kanonersky Forestry of Pavlodar Region, 28 Apr 1955, Elagina s.n. (LE!); between Semipalatinsk and Uluguz Station, 30 Apr 1912, Shishkin s.n. (LE!); near the southern part of Semipalatinsk District, left bank of the Irtysh River 20 versts east of Semipalatinsk, 7 May 1914, Shipchinsky 45 (LE!). **Syrt:** Beam near Uralsk, 13 Apr 1911, Borodin s.n. (BRNU 095254!; LE!); near Uralsk in Stepanov Garden, 3 May 1924, Larin s.n. (AA!); near Uralsk Province, outskirts of Bannov Garden in a steppe depression, 1 Apr 1918, Larin s.n. (AA!); near Uralsk, slope of the old river escarpment of Chagan near Prorva, 23 Apr 1911,

Borodin 336 (LE!). **Tobol-Ishim:** Naurzum State Nature Reserve, 1 May 2010, students (LE!); near the vicinity of Zhitikara [Zhetikara], 14 Apr 2012, students s.n. (KSPI!); near the village of Stepanovka, 12 May 2009, students s.n. (KSPI!); near the village of Peshkovka, 4 May 2010, students s.n. (KSPI!); near the village of Taranovskoye, 6 May 1978, students s.n. (KSPI!); near the village of Kenaral, 8 May 1994, students s.n. (KSPI!); near the village of Peshkovka, 1 May 2009, students s.n. (KSPI!); near the village of Zarechny, natural landmark "Urochishche Kamennoye Ozero", 29 Apr 1978, students s.n. (KSPI!); near the village of Verenka, natural landmark "Verensky Pine Forest", 1 May 2009, Dubenyuk s.n. (KSPI!); near the village of Novonezhinka, 10 May 1968, students s.n. (KSPI!); near the village of Kazakhstanets, 15 May 1996, students s.n. (KSPI!); near Mikhailovskoye Forestry, 6 May 1978, students s.n. (KSPI!); near the village of Asenkritovka, 6 May 1978, students s.n. (KSPI!); near the village of Kamensk-Uralsky, 27 Apr 2009, students s.n. (KSPI!); near the village of Shili, 1 May 1978, students s.n. (KSPI!); near the village of Mikhailovka, 30 Apr 2009, Dubenyuk s.n. (KSPI!); near the city of Kostanay, 19 Jun 1968, Sokolov s.n. (AA!); near the Khutor Zhukova, 1 Apr 1930, Dmitriev s.n. (AA!); near Akmola District, Sovenkovsky Experimental Site, Steppe, 20 May 1920, Sheludyakova s.n. (AA!); near Akmola District, Sovenkovsky Experimental Site, slopes and depressions, 26 Apr 1920, Sheludyakova s.n. (AA!); near Kargaly-Tau, Kara-Bulak Station, 1909, Savich and Kucherovskaya 155 (LE!); near Kostanay District, meadow steppe along the Tobol River, 27 Apr 1921, Pavlov s.n. (LE!); between Bulayevo Station and Konyukhovo Village, 26 Jul 1913, Ziles 387 (LE!); near Petropavlovsk District, slopes of a ravine with clay soil near the railway closer to Petropavlovsk, 11 May 1914, Ganeshin 63 (LE!); Petropavlovsk District, steppe beyond the railway near Petropavlovsk, 11 May 1914, Ganeshin s.n. (LE!); near Kostanay District, steppe between Troitsk and Kostanay, May 1908, Krasheninnikov s.n. (LE!); near the city of Kostanay, steppe, 1 May 1904, Fedoseev 8 (LE!); near Turgay District, Nauryzumskaya Volost, edge of Nauryzum Pine Forest, among shrubs, 24 May 1909, Savich and Kucherovskaya 337 (LE!); near Kostanay District, vicinity of Imanbaev Wintering [Yemankino], 6 May 1907, Ostrovskih s.n. (LE!); near Nauryzum Reserve, south of Egin-Bulak, 4 May 1935, Levitzky s.n. (LE!); feather grass-fescue steppe on the southeastern edge of Nauryzum, 26 May 1909, Savich and Kucherovskaya 391 (LE!); near Kostanay District, shrubs along the Tobol River floodplain near Kostanay, 20 May 1921, Korenev 229 (LE!); near Kostanay District, Ara-Karagay Forest near the middle cordon on a meadow, 28 Apr 1921, Pavlov 229 (LE!); near Petropavlovsk District, steppe beyond the railway near Petropavlovsk, 11 May 1914, Ganeshin s.n. (LE!); 0.7 km east of the water tower siding between Kiyaly-Smirnovo Station, Petropavlovsk-Kokchetav Railway, 30 May 1928, Shapovalov 9 (LE!); 18 km northwest of Dalny Station, 18 Jun 1955, Isachenko et al. 2962 (LE!). **Turgay:** Near the vicinity of Torgay settlement, 2 May 2010, students s.n. (KSPI!); near the vicinity of Zheleznodorozhnyj settlement, 1 May 2009, Andreeva s.n. (KSPI!); near the Damdy River, 1 May 2010, Perezhogin and Borodulina s.n. (KSPI!); near the Damdy River, 24 Apr 2011, students s.n. (KSPI!); near the central estate of the Kiev State Farm, 15 May 1954, Kurochkina s.n. (AA!; LE!). **Ulutau:** Along the bank of a stream

near Ulutau picket, 2 Jul 1914, Ganeshin 1256 (LE!); near the vicinity of Tersakkan village, Tersakkan River bank, 22 May 2010, Kupriyanov and Mihajlov s.n. (KUZ!); near the vicinity of Ulytau village, Ulytau Mountains, Aydarly area, 25 Jun 2017, Kupriyanov and Hrustaleva s.n. (KUZ!). **Western Upland:** Upper reaches of the Ulken-Kundyzdy River, 19 May 1959, Denisova 1031 (MW 0832030!); Ereymentau, hilly landscape ca. 6 km SSE of the village, 454 m a.s.l., 27 Jun 2014, Danihelka et al. s.n. (BRNU653564); Ereymentau, hilly landscape ca. 6 km SSE of the village, 446 m a.s.l., 27 Jun 2014, Chytrý and Hájek s.n. (BRNU 653565); Topar, ca. 6 km E of the village, 30 Jun 2014, Danihelka et al. s.n. (BRNU 653944); Buiraatau State National Nature Park, vicinity of the Belodymovka cordon, Mount Akdym, 7 May 2012, Hrustaleva et al. s.n. (KUZ!); right bank of the Kairakty River, 22 May 1954, Lushpa s.n. (AA!); near the Ostrovsky [Tarasovka] State Farm, 10 May 1954, Lushpa s.n. (AA!); 20 km south of the Tomzyk grave, 8 Jun 1955, Isachenko et al. 2759 (LE!); 90 km southeast of Karaganda, Karashoky Mountains, 30 May 1965, Vasilevich et al. 2042 (LE!); Kyrgyz [Kazakh] cemetery near Akmolinsk, 22 May 1914, Ganeshin 246 (LE!); near Kurgaldzhyn settlement, 8 May 1979, Sidorova s.n. (LE!); vicinity of Korgalzhyn village, 29 Apr 2019, Kubentayev 6655 (LE!; NUR!); vicinity of Karaegin village, 29 Apr 2019, Kubentayev 5955 (NUR!; LE!); near Lake Kurgaldzhin, Karazhar area on the way to Kurgaldzhino settlement, 1 Jun 1976, Turganbekova s.n. (AA!); 20 km south of Karaganda, 15 May 1969, Poschkurlat s.n. (MW 0832019!); 15 km south of Karaganda, May 1969, Poschkurlat s.n. (MW 0832021!); 12 km east of Zhana-Arka station, 1 May 1958, Rachkovskaya s.n. (LE!); 1.5 km east of Zhana-Arka station, 28 Apr 1958, Rachkovskaya 5031 (LE!); near the Zharkul-Shoindykul Plateau, 27 Apr 1959, Borisova 3 (LE!); near Mount Bolshoy Kokshengir, 9 May 1959, Karamysheva s.n. (LE!).

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